91602
new 82-10

ontario hydro
research division

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research If

To Mr. J.V. Doyle
Manager
Civil Works Department
Thermal and Hydraulic Generation Division

Attn: Mr. G.F. Smith

STEWARTVILLE GS
NEW GEOTECHNICAL INSTRUMENTATION

C.B. Cragg

Installation of a normal pendulum, an inverse pendulum and alignment survey monuments at Stewartville GS dam are described. Initial pendulum readings are also presented.

1.0 INTRODUCTION

A review of the Stewartville GS instrumentation /1/ recommended that new instrumentation be installed to monitor deformation to assess performance, to monitor unusual conditions and to provide information for future assessment of performance. This report documents the installation of the survey monuments, normal pendulum and inverse pendulum recommended for the deformation monitoring. Initial readings of the pendulums are also included.

2.0 SITE DESCRIPTION

Stewartville GS is a concrete gravity structure with a crest length of 1350 feet and a maximum height of 190 feet. Completed in 1948, this dam was extensively instrumented as part of a major research program/2/. Much of this instrumentation was not maintained after the research program was completed in 1955/3/. The dam is founded on crystalline limestone which contains zones of erodable materials. Recently, extensive amounts of work have been completed to repair and control foundation leakage.

3.0 INSTRUMENTS INSTALLED

The purpose of the new instrumentation is to provide information on structural movements in both the vertical and horizontal directions. The new instruments installed in the dam include:

(a) 1 normal pendulum in the inspection tunnel at chainage 5+06.

job	file	date	report no.
43-145-575	843.12	November 3, 1987	87-24-K

(b) 1 inverse pendulum adjacent to the normal pendulum at chainage 5+10 approximately.

(c) 7 survey brass caps in the dam deck.

(d) 1 concrete bench mark in the left abutment.

Figure 1 shows the project in plan and the location of these instruments.

4.0 NORMAL PENDULUM

The normal pendulum is located on the upstream side of the inspection tunnel, near the base of the south inspection tunnel stairway, at chainage 5+06. This location was selected because it is near the site of past leakage and will provide the best control for deck surveys. In order to accommodate the reading table and reduce restriction of the tunnel the construction joint opening was widened (Figure 2 and Figure 3). The normal pendulum hole was drilled beside the construction joint drain since, after calcite removal, the drain was obstructed with rebar which prevented the insertion of the protective casing for the pendulum wires. The pendulum hole was drilled NQ size and the orientation of the borehole was logged and is included in this report as Figure 4. A rain guard was installed over the reading table.

An initial set of readings of the normal pendulum and microlevel readings were performed. These readings will be used to monitor deformations of the main dam. The microlevel readings taken on the top of the reading table with a portable tiltmeter or microlevel (Figure 5) indicate the slope of the table in degrees which will identify if the reading table has been disturbed. The initial readings of the normal pendulum and the micro level readings are included in this report as Appendix I.

5.0 INVERSE PENDULUM

The inverse pendulum was installed adjacent to the normal pendulum on the upstream wall of the inspection tunnel at chainage 5+10 approximately. The inverse pendulum hole was drilled NQ size from the base of the inspection tunnel to a depth of 103 feet. Drilling procedures that were developed by Hydro Quebec/4/ were used in the installation. Figure 6 shows the location and amount of correction that was required in drilling the pendulum hole. The material encountered by the drill consisted of 63 feet 6 inches of concrete followed by 39 feet 6 inches of crystalline limestone which was weathered and faulted at some depths. The drill core was examined and logged and is included in this report as Figure 7. During drilling, wood was encountered and the drill rods dropped 6 inches when passing the concrete to rock interface. Drill water was also lost at this location which is approximately 64 feet below the base of the inspection tunnel. It is believed these features represent the formwork for the box drain rather than the drain itself. To protect the drain, beads of weld were placed on the outside of the pendulum casing to wedge it into the hole above the box drain and grout was used only in the rock, below the drain.

An initial set of readings of the inverse pendulum, including the autocentering device/5/ and microlevel readings, were performed. These readings will be used to monitor where deformations of the main dam have occurred. The microlevel readings will identify if the reading table has been disturbed. The initial readings of the inverse pendulum and microlevel readings are included in this report as Appendix I. The autocentering device readings are included in this report as Appendix II.

6.0 SURVEY MONUMENTS

Seven survey monuments, consisting of 2.5 inch diameter brass caps engraved "CIVIL WORKS, 1986", were installed across the top of the dam at 1+39, 2+58, 4+05, 5+05, 6+50, 7+26 (center line pier) and 8+14 Since these brass caps will be used for elevation and alignment monitoring they have been established on line.

A new benchmark was established, on line with the new brass caps, on the left side of the dam at chainage 0-10 (Figure 1). The benchmark consists of a survey brass cap of the same type used for the survey monuments. This cap is grouted in a concrete crane pad founded on rock and located beside the top of dam access road.

7.0 DISCUSSIONS

The installation of inverse and normal pendulums was completed at Stewartville GS and an initial set of readings was obtained. In addition 8 brass caps, one which serves as a benchmark, have been installed across the top of the dam.

An annual inspection of the apparatus will be required to ensure that these instruments remain in good operating condition.

Approved by:

for T.W. Klym
Manager
Civil Research Department

Prepared by:

C.B. Cragg
Senior Engineer
Soil Sciences Section

Reviewed by:

for T.J. Carmichael
Supervising Engineer
Soil Sciences Section

JBE:LM

REFERENCES

1. Cragg, C.B.H. "Stewartville GS - Proposed New Instrumentation - 1986". Research Division Report No S86-23-K.

2. Gung, G. and W.G. Morison. "Installation Report Dam Instrumentation Program". Research Division Report No 52-451, 1952.

3. Gung, G. and W.G. Morison. "Measurements of the Structural Behaviour of Concrete Gravity Dams". Research Division Report No 54-533, 1955.

4. L. Dubreuil and R. Hamelin. "Vertical Drilling of Inverse Pendulum Holes". Second Canadian Symposium on Mining, Surveying and Rock Deformation Measurements, Kingston, Ontario, 1974.

5. R. Hamelin and B. Boyer. "Instruments for Monitoring the Profile of Vertical and Inclined Holes". 35th Canadian Geotechnical Conference, Montreal, 1982.

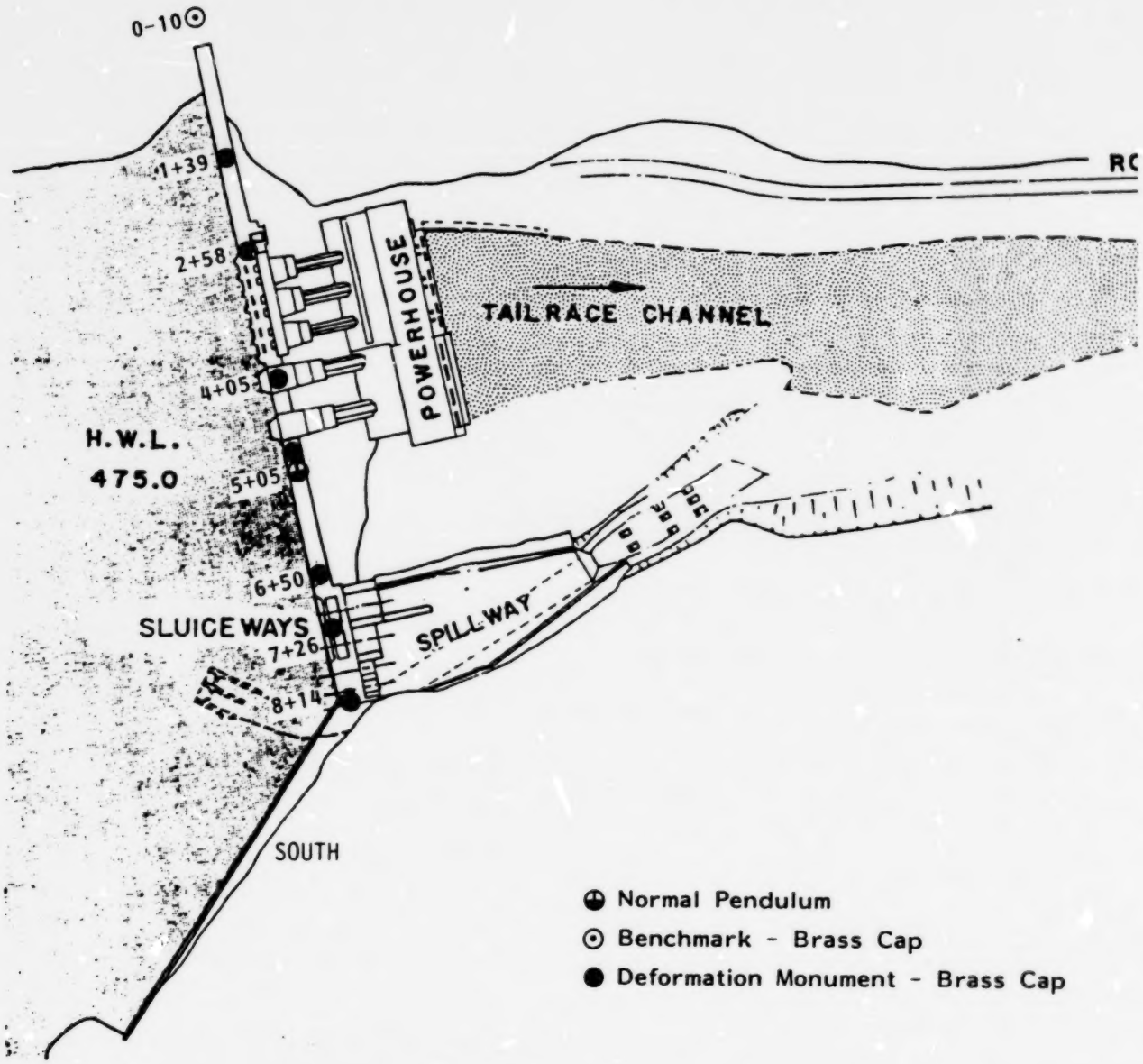
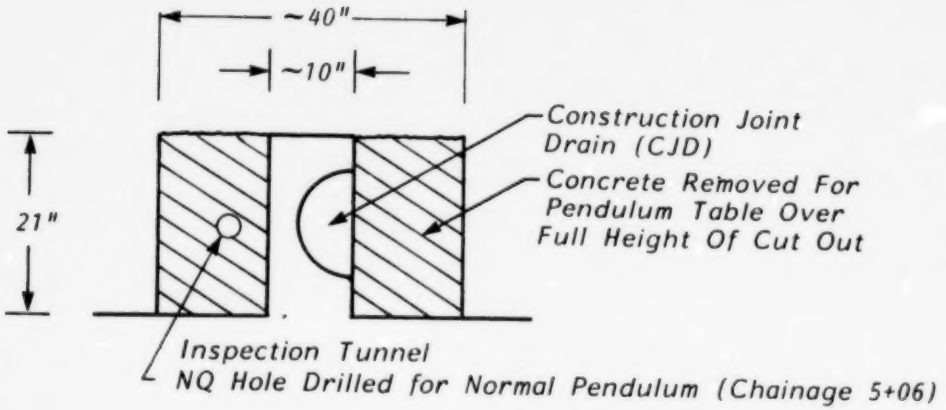
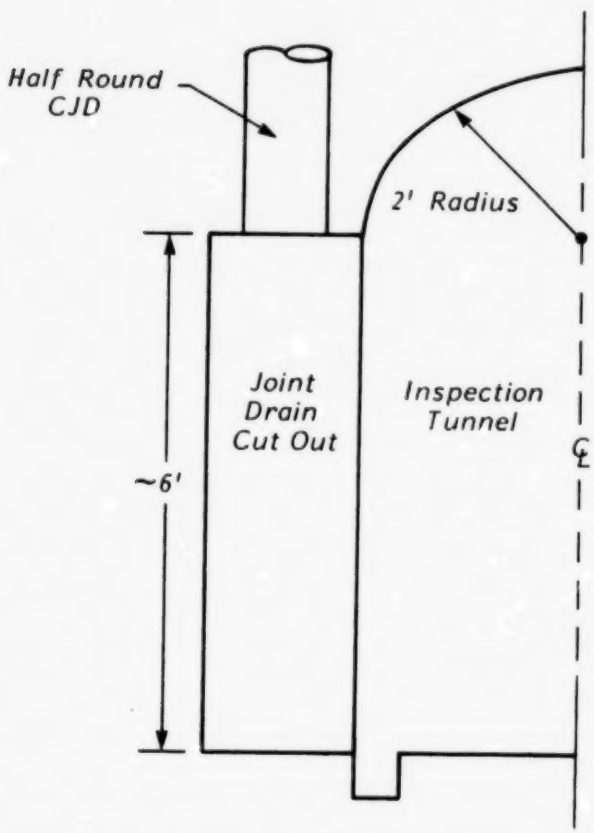


FIGURE 1

PLAN OF STEWARTVILLE GS
NEW INSTRUMENT LOCATIONS


~40"
~10"
21"
Construction Joint Drain (CJD)
Concrete Removed For Pendulum Table Over Full Height Of Cut Out
Inspection Tunnel
NQ Hole Drilled for Normal Pendulum (Chainage 5+06)



Chainage: 5+05

FIGURE 2

STEWARTVILLE GS
CONSTRUCTION JOINT DRAIN

172126-RD

87-24

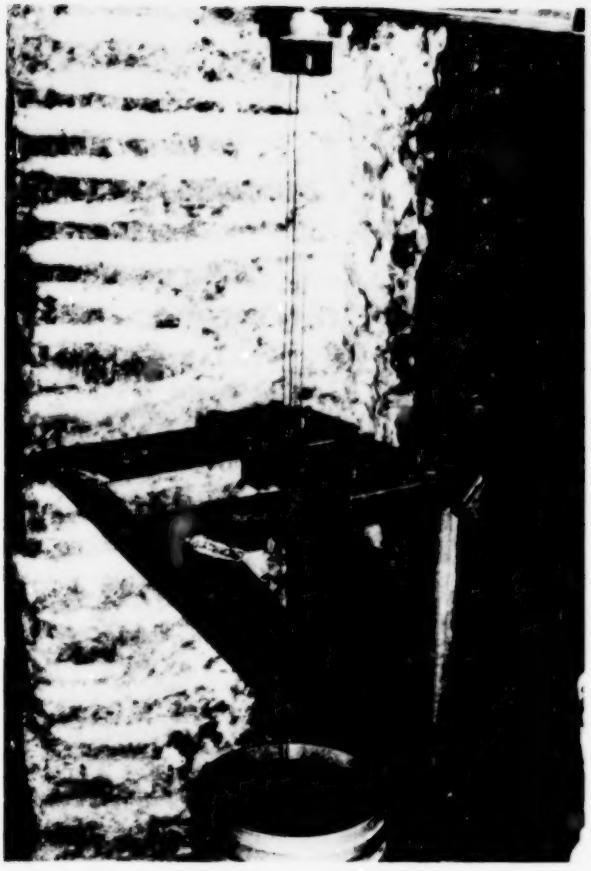


FIGURE 3

STEWARTVILLE GS
NORMAL PENDULUM

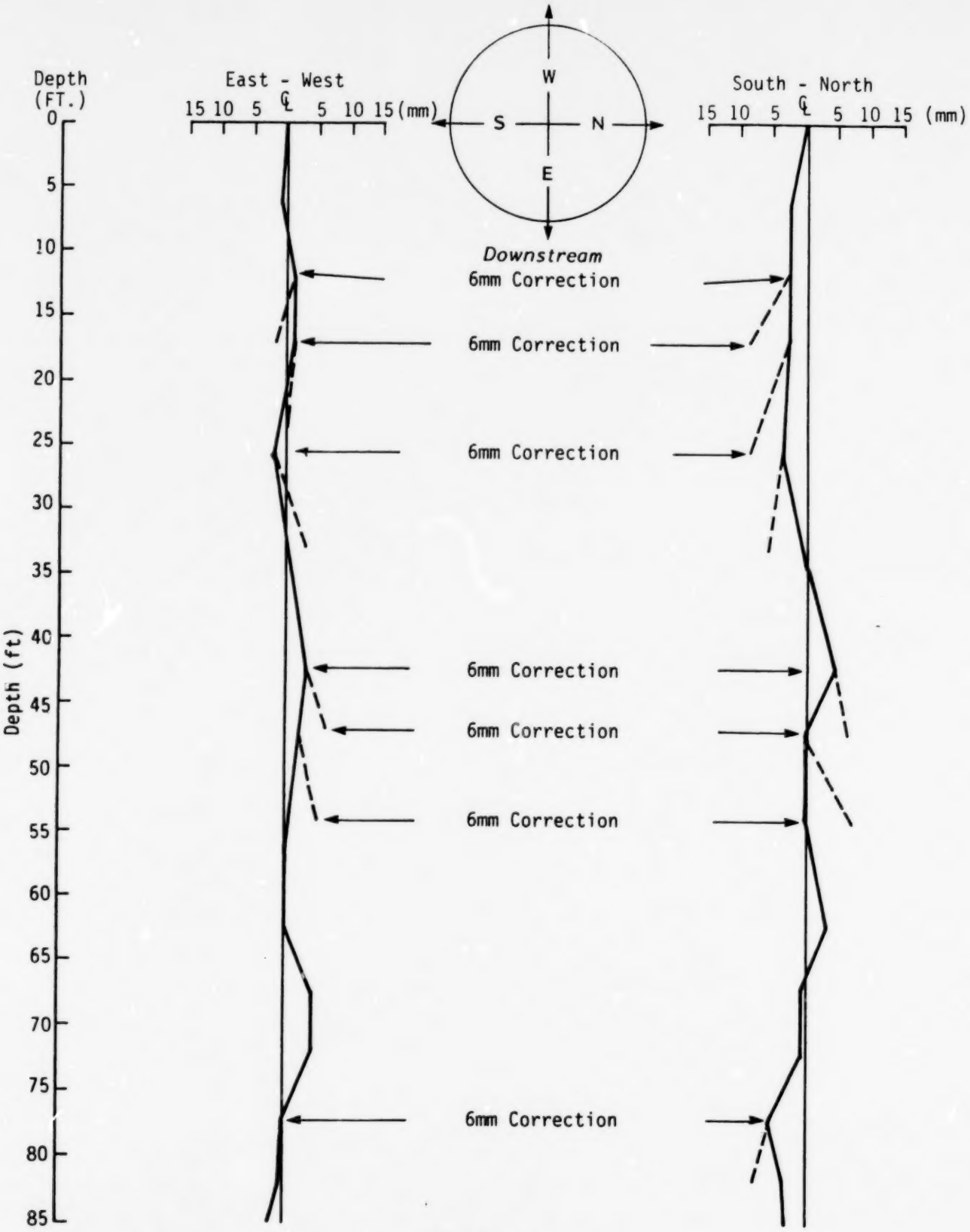


FIGURE 4

STEWARTVILLE G.S.
NORMAL PENDULUM BOREHOLE PROFILE

173753-RD
Page 1 Of 2

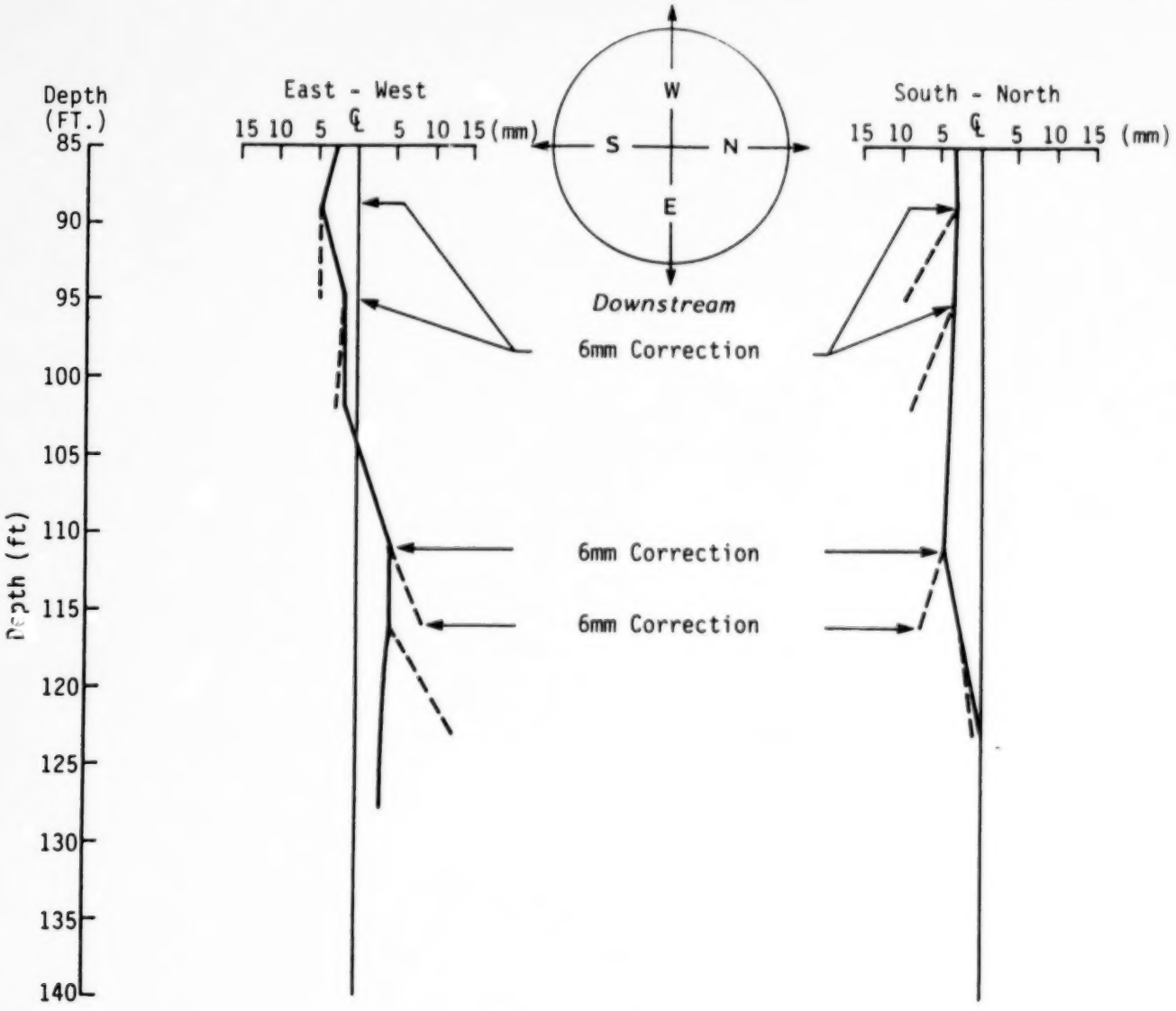


FIGURE 4 (CONT'D)

STEWARTVILLE GS
NORMAL PENDULUM BOREHOLE PROFILE

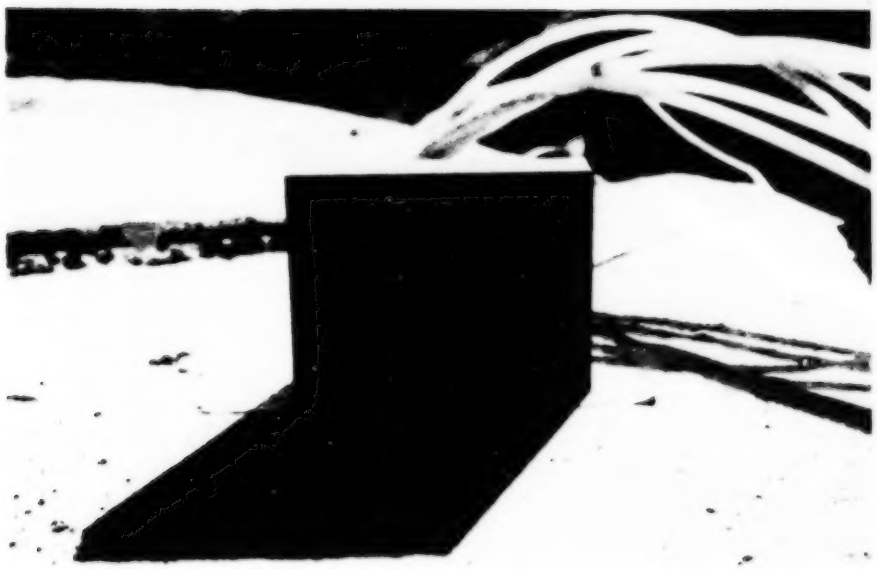


FIGURE 5

PORTABLE MICRO LEVEL USED TO
MONITER SLOPE OF READING TABLES

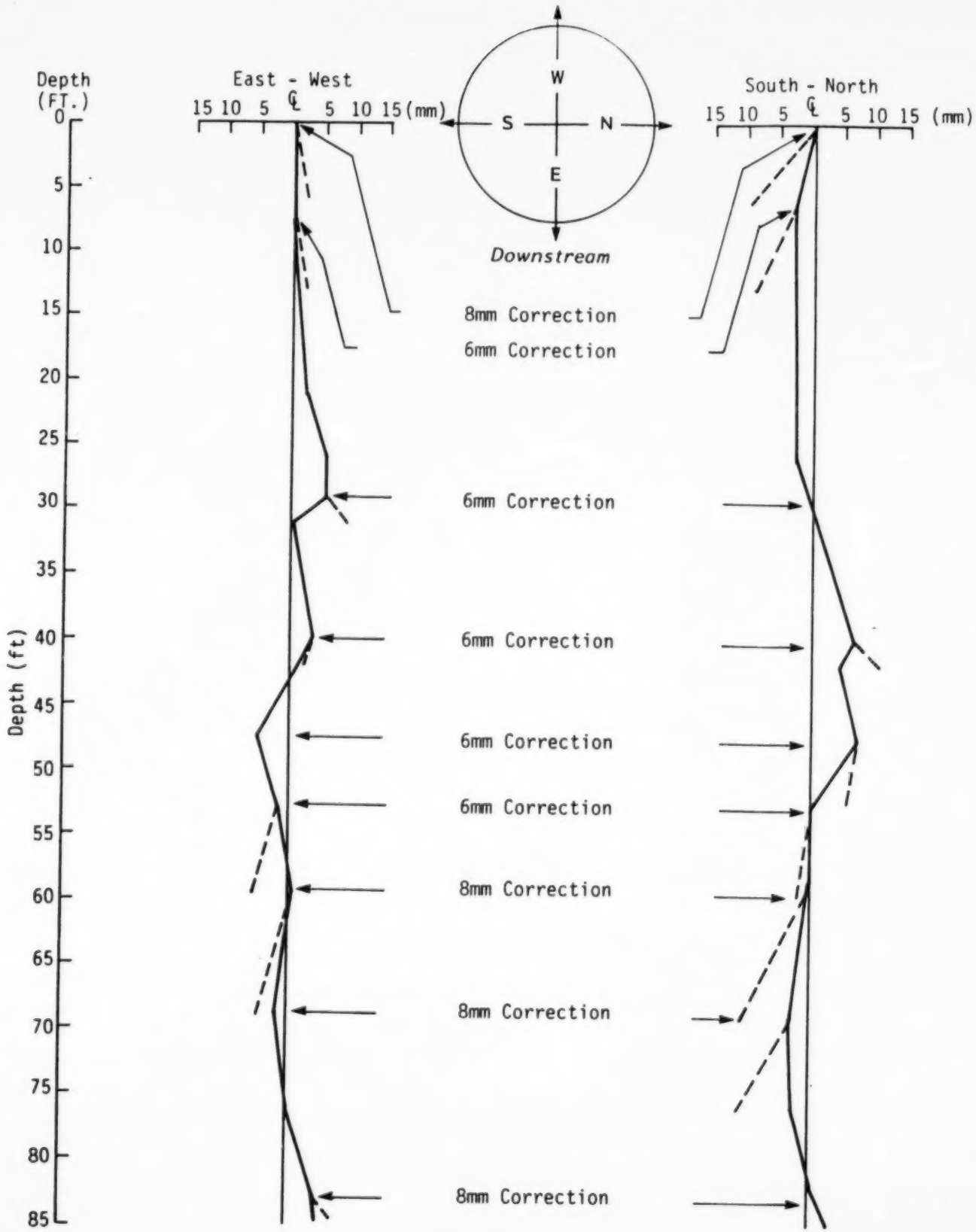


FIGURE 6

STEWARTVILLE GS
INVERSE PENDULUM BOREHOLE PROFILE

173752-RD
Page 1 Of 2
87-24

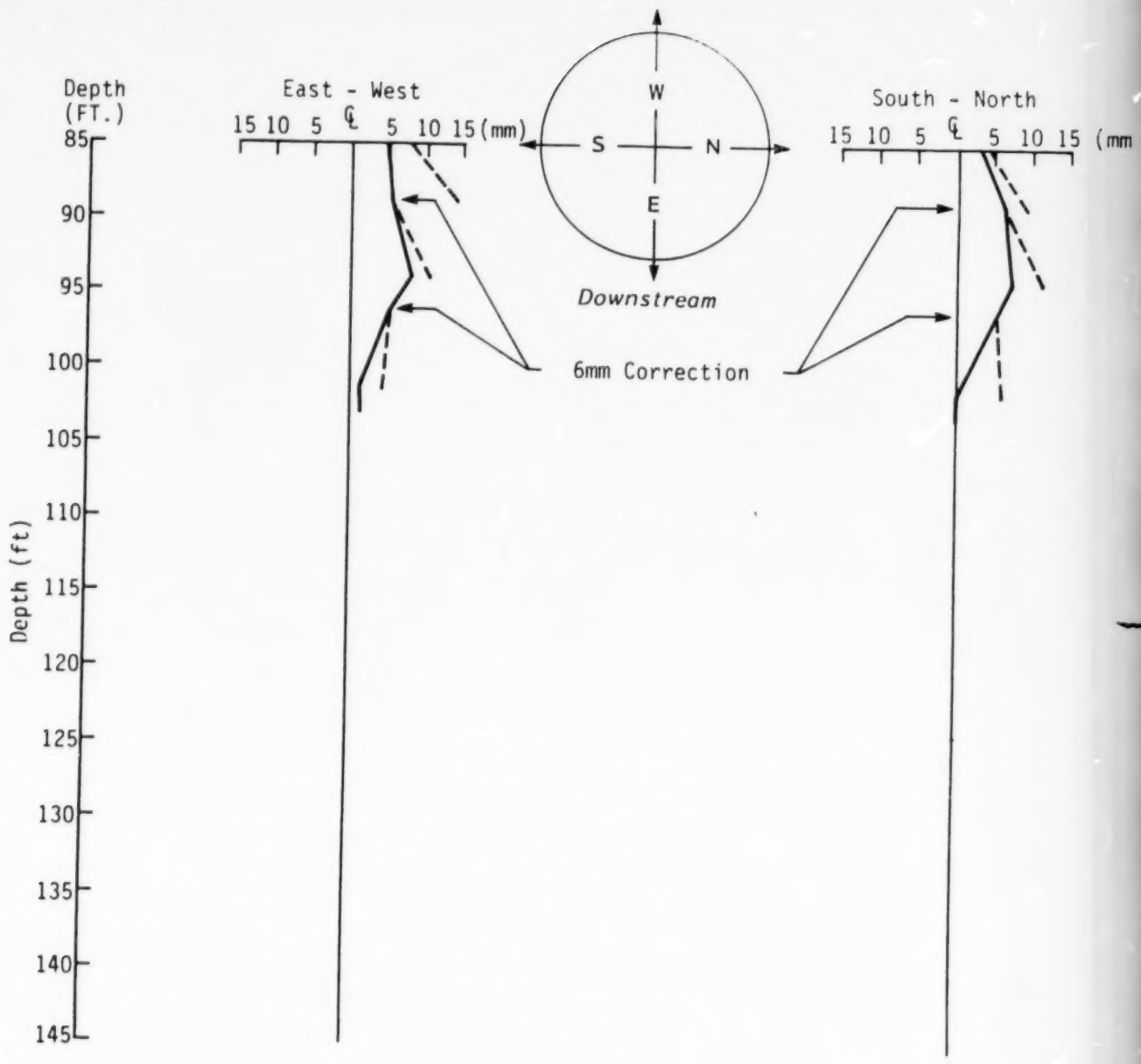


FIGURE 6 (CONT'D)

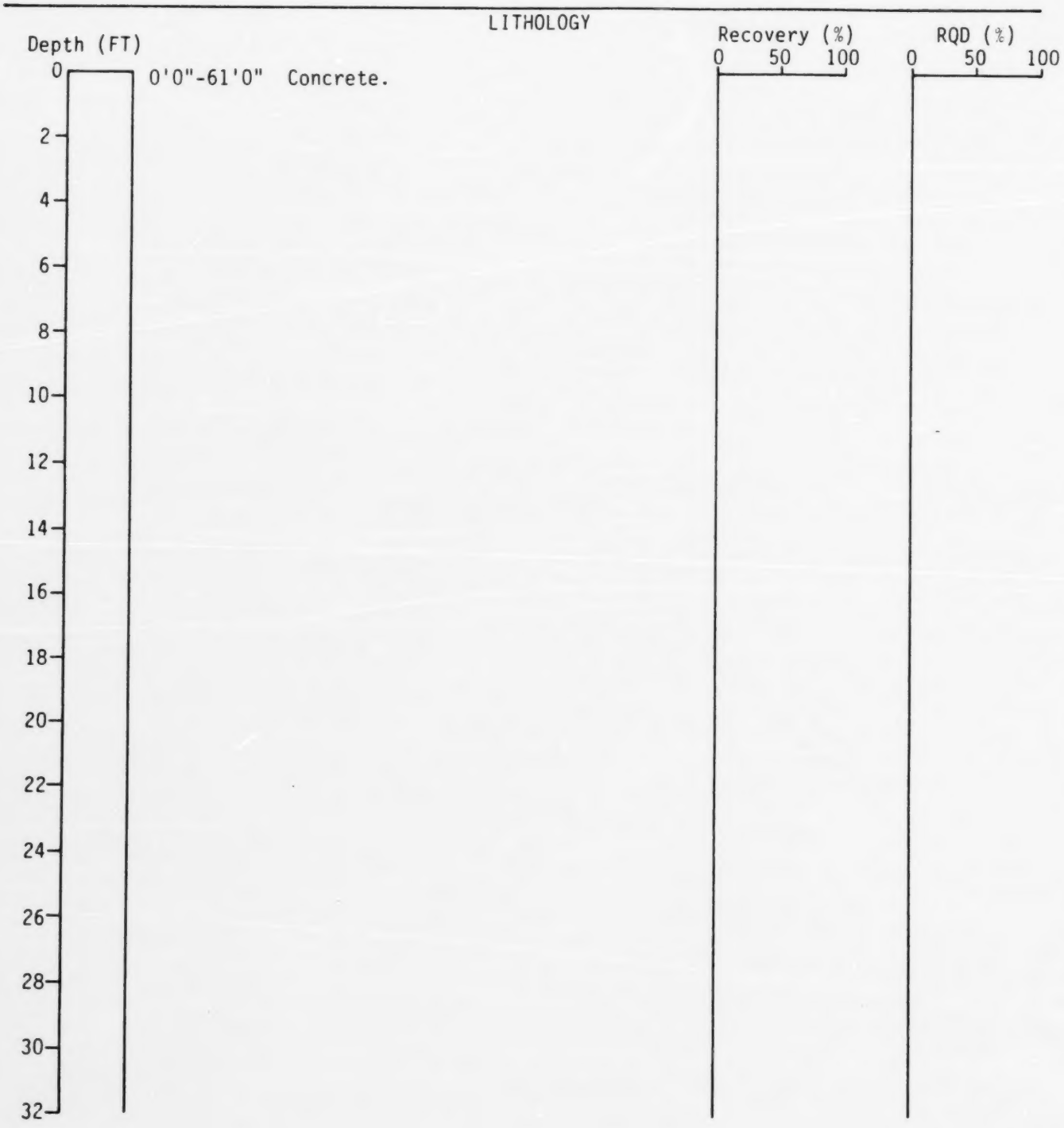
STEWARTVILLE GS
INVERSE PENDULUM BOREHOLE PROFILE

FIGURE 7

BEDROCK LITHOLOGY

Project: Stewartville
Borehole No.: None

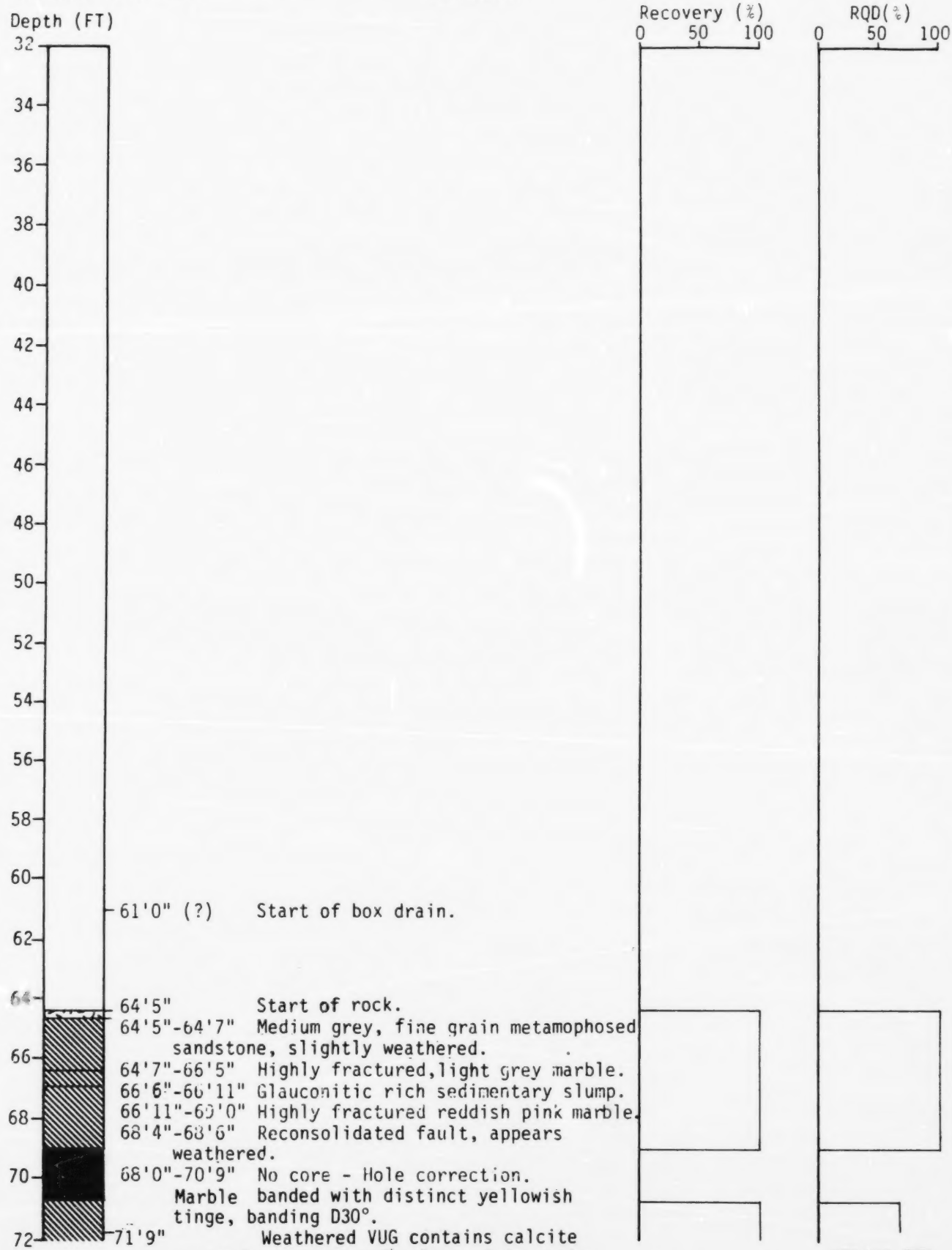
Location: Inverse Pendulum
Chainage:
Collar Elev.:
Dip:
Azimuth:



87-24
173667-RD

Project: Stewartville
Borehole No.: None

*FIGURE 7 CONT'D

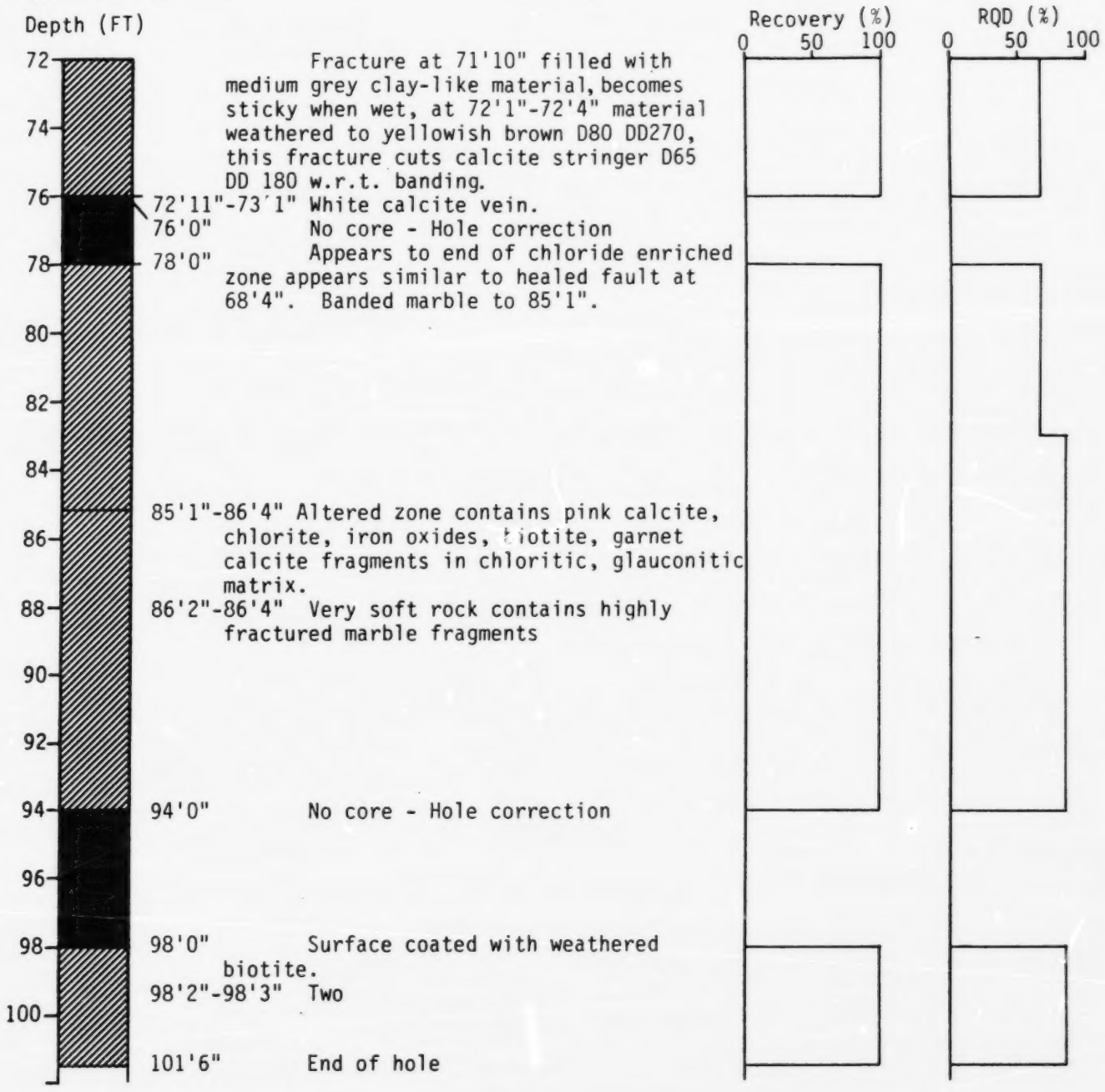


173668-RD
87-24

FIGURE 7 CONT'D

Project: Stewartville
Borehole No.: None

LITHOLOGY



Fracture at 71'10" filled with medium grey clay-like material, becomes sticky when wet, at 72'1"-72'4" material weathered to yellowish brown D80 DD270, this fracture cuts calcite stringer D65 DD 180 w.r.t. banding.

72'11"-73'1" White calcite vein.

76'0" No core - Hole correction

78'0" Appears to end of chloride enriched zone appears similar to healed fault at 68'4". Banded marble to 85'1".

85'1"-86'4" Altered zone contains pink calcite, chlorite, iron oxides, biotite, garnet calcite fragments in chloritic, glauconitic matrix.

86'2"-86'4" Very soft rock contains highly fractured marble fragments

94'0" No core - Hole correction

98'0" Surface coated with weathered biotite.

98'2"-98'3" Two

101'6" End of hole

87-24
173669-RD

GEOLOGIC KEY

Limestone

Sandy Limestone

Shaley Limestone

Sandy, Shaley Limestone

Dolostone

Sandstone

Metamorphosed Sandstone

Marble

Banded Grey Marble

No Core

D — *Dip of a Feature*

DD — *Directional of Dip of A Feature with Respect to the Direction in Which the Principal Geologic Feature such as Bedding of Metamorphic Banding*

APPENDIX I

Initial Readings for Normal and Inverse Pendulums

APPENDIX I

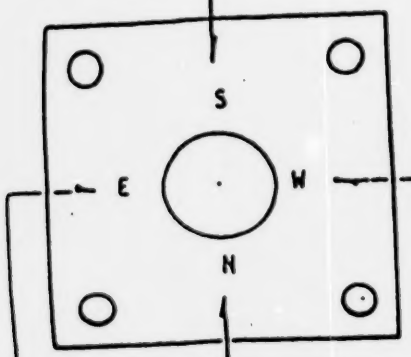
STEWARTVILLE GS

(Factory MIC)

DATE: April 7/87

READ BY: A. Morton & D. Fraser

Inverted Pendulum



original reading 1.571
current reading 1
2
3

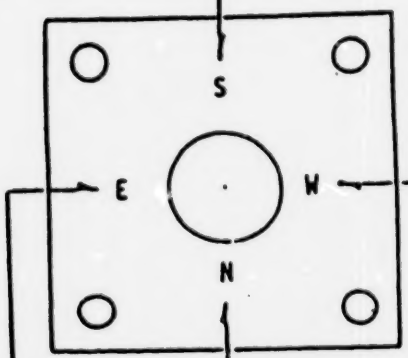
original reading 1.538
current reading 1
2
3

original reading 1.497
current reading 1
2
3

original reading 1.530
current reading 1
2
3

MICRO LEVELS E-W (FS) + 0.00°
N-S (FE) + 0.10°

Normal Pendulum



original reading 1.513
current reading 1
2
3

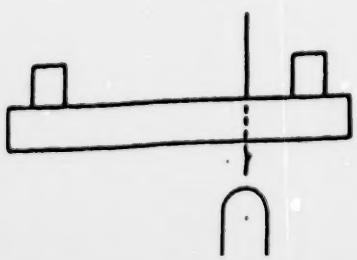
original reading 1.687
current reading 1
2
3

original reading 1.552
current reading 1
2
3

original reading 1.388
current reading 1
2
3

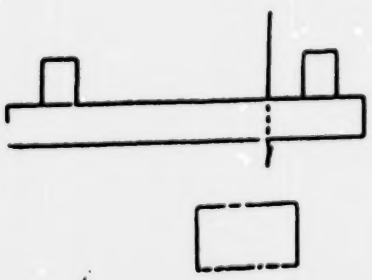
MICRO LEVELS E-W (FS) + 0.01°
N-S (FE) - 0.13°

Invar/Pin



original reading 0.709
current reading 1
2
3

Invar/Block



original reading 2.218
current reading 1
2
3

INVERSE
3.073
3.073

READING CHECK
= sum of N & S should = 3.073
= sum of E & W should = 3.070
READINGS ARE IN INCHES

NORMAL

87-24

APPENDIX II

Inverse Pendulum - Initial Autocentering Device Readings

Inverted Pendulum
Datum Readings

Page 1 of 1

DATE: Dec 3/86

TEMP.:

Observer AM & DF

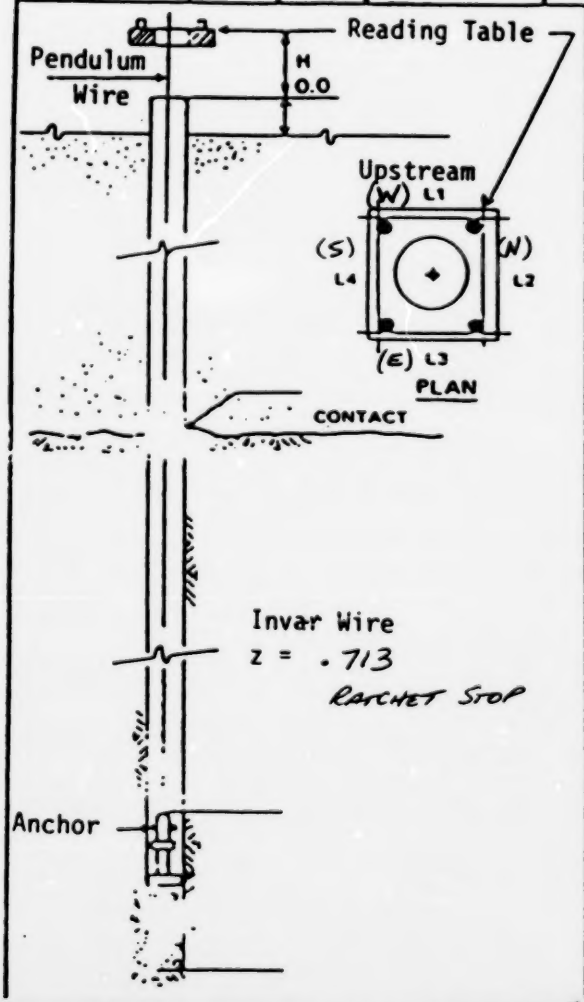
Marker

Chainage 57 10

Elevation

PROJECT: STEWARTVILLE G.S.

Depth (ft)	Axis	Rdg No	Reading Inches	Position	Actual Position	Original Position	Displacement
Reading Table H =	X	L2	1.534	.006	(Px) .006		
		L4	1.545				
		L2					
		L4					
	Y	L1	1.582	-.047	(Py) -.047		
		L3	1.488				
		L1					
		L3					



Position of centre of the reading table relative to the pendulum anchor

$x = \frac{L4 - L2}{2}$ $y = \frac{L3 - L1}{2}$

Auto centering device
Position of the wire, at various depths relative to the pendulum anchor

$x = \frac{L2 - L4}{2} + Px$

$y = \frac{L1 - L3}{2} + Py$

Table Constant x = 3.123

y = 3.123

Wire Diameter .050"

MICRO LEVEL DATUMS N-S +.15"
E-W +.07"

DATE: [illegible]

TEMP.: _____

[illegible] Position Indicator

AUTO CENTERING DEVICE

_____ of 2

AM & DF

ST 10

SIZEWELL G.S. PLOT: _____

DEPTH FT	AXIS		READING (INCHES)	POSITION	RESULTANT POSITION	ORIGINAL POSITION	DISPLACEMENT
0	X	L2	1.748	.219	.219		
		L4	1.322				
		L2					
		L4					
	Y	L1	1.578	-.004	-.004		
		L3	1.491				
		L1					
		L3					
5.5	X	L2	1.936	.408	.408		
		L4	1.133				
		L2					
		L4					
	Y	L1	1.771	.189	.189		
		L3	1.299				
		L1					
		L3					
10.5	X	L2	1.927	.400	.400		
		L4	1.140				
		L2					
		L4					
	Y	L1	1.783	.210	.210		
		L3	1.279				
		L1					
		L3					
15.5	X	L2	1.822	.292	.292		
		L4	1.251				
		L2					
		L4					
	Y	L1	1.731	.148	.148		
		L3	1.342				
		L1					
		L3					

P_x: .006

P_y: -.047

DATE: [illegible]

TEMP.: _____

INCLINOMETER AUTO GATHERING DEVICE

STEWARTSVILLE G.S. PLOT: _____

AMT OF 5+10

DEPTH (FT)	AXIS		READING (INCHES)	POSITION	ACTUAL POSITION	ORIGINAL POSITION	DISPLACEMENT
20.5	X	L2 ↓	1.738	.204	.204		
		L4 ↓	1.343				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.644	.061	.061		
		L3 ↓	1.428				
		L1 ↑					
		L3 ↑					
25.5	X	L2 ↓	1.681	.144	.144		
		L4 ↓	1.405				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.561	-.022	-.022		
		L3 ↓	1.511				
		L1 ↑					
		L3 ↑					
30.5	X	L2 ↓	1.548	.016	.016		
		L4 ↓	1.529				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.505	-.079	-.079		
		L3 ↓	1.569				
		L1 ↑					
		L3 ↑					
35.5	X	L2 ↓	1.386	-.149	-.149		
		L4 ↓	1.696				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.624	.040	.040		
		L3 ↓	1.451				
		L1 ↑					
		L3 ↑					

Px: -.006

Py -.047

DATE: Dec 1987 | Mid Cleaning Drill | 2015

TEMP.: | AM 4 OF

STINAKEVILLE C.S. PLOT: | STIO

Pn: 006

Py -.047

DEPTH (FT)	AXIS		READING (INCHES)	POSITION	AERIAL POSITION	ORIGINAL POSITION	DISPLACEMENT
40.5	X	L2 ↓	1.253	-.279	-.279		
		L4 ↓	1.823				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.386	-.195	-.195		
		L3 ↓	1.682				
		L1 ↑					
		L3 ↑					
45.5	X	L2 ↓	1.250	-.280	-.280		
		L4 ↓	1.822				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.764	.180	.180		
		L3 ↓	1.309				
		L1 ↑					
		L3 ↑					
50.5	X	L2 ↓	1.527	-.006	-.006		
		L4 ↓	1.551				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.833	.250	.250		
		L3 ↓	1.239				
		L1 ↑					
		L3 ↑					
55.5	X	L2 ↓	1.755	.225	.225		
		L4 ↓	1.318				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.874		.290		
		L3 ↓	1.201				
		L1 ↑					
		L3 ↑					

DATE: Dec 3/86

TEMP.:

AUTO CENTERING DEVICE

STEWIACKVILLE G.S. PLOT:

AM4DE

5210

DEPTH (FT)	AXIS		READING (INCHES)	POSITION	ACTUAL POSITION	ORIGINAL POSITION	DISPLACEMENT
60.5	X	L2 ↓	1.865	.351	.351		
		L4 ↓	1.196				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.838	.254	.254		
		L3 ↓	1.236				
		L1 ↑					
		L3 ↑					
65.5	X	L2 ↓	1.978	.445	.445		
		L4 ↓	1.101				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.865	.280	.280		
		L3 ↓	1.211				
		L1 ↑					
		L3 ↑					
70.5	X	L2 ↓	1.928	.397	.397		
		L4 ↓	1.147				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.840	.305	.305		
		L3 ↓	1.243				
		L1 ↑					
		L3 ↑					
75.5	X	L2 ↓	1.768	.236	.236		
		L4 ↓	1.308				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.744	.153	.153		
		L3 ↓	1.344				
		L1 ↑					
		L3 ↑					

Px: .006

Py -.047

DATE: [illegible]

TEMP.: _____

INDICATOR READOUT AT AUTO CENTERING DEVICE

STEWARTSVILLE G.S. PLOT: _____

Amp of 5710

DEPTH (FT)	AXIS		READING (INCHES)	POSITION	ACTUAL POSITION	ORIGINAL POSITION	DISPLACEMENT
80.5	X	L2 ↓	1.526	-.004	-.004		
		L4 ↓	1.546				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.545	-.044	-.044		
		L3 ↓	1.538				
		L1 ↑					
		L3 ↑					
85.5	X	L2 ↓	1.365	-.164	-.164		
		L4 ↓	1.705				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.342	-.241	-.241		
		L3 ↓	1.730				
		L1 ↑					
		L3 ↑					
90.5	X	L2 ↓	1.240	-.294	-.294		
		L4 ↓	1.840				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.325	-.260	-.260		
		L3 ↓	1.750				
		L1 ↑					
		L3 ↑					
95.5	X	L2 ↓	1.273	-.256	-.256		
		L4 ↓	1.797				
		L2 ↑					
		L4 ↑					
	Y	L1 ↓	1.411	-.173	-.173		
		L3 ↓	1.662				
		L1 ↑					
		L3 ↑					

P_x: .006

P_y = .047

DISTRIBUTION

Mr. J.V. Doyle	Thermal and Hydraulic Gen Div, A12H18
Mr. G.F. Smith (2)	Thermal and Hydraulic Gen Div, A12H17
Mr. A.R. Bennett (2)	Thermal and Hydraulic Gen Div, A12H14
Dr. T.W. Klym/Mr. T.J. Carmichael	Civil Research
Mr. C.B. Cragg	Civil Research

Section File (1) KR252
Public Reference Centre
Editorial Section (2)
Office Copies (5)
Extra Copies (5)

- last page -